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MEDICINAL VALUE OF SEAWEEDS – A REVIEW

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ABSTRACT

Seaweeds are one of the most important living resources of the ocean and are one of the largest producers of biomass in the marine environment. They produce a wide variety of chemically active metabolites in their surroundings, potentially as an aid to protect themselves against the other settling organisms. These biogenic molecules impart the uniqueness of chemical diversity in seaweeds compared to other plants. Which owe them multitude of medicinal properties, because of that they are often been used as a food for people who are sick and has been credited with health-giving properties and have gained importance as medicinal sources. Present review highlights a state of art on the medicinal value of seaweeds and their exploitation scenario on a global scale.

KEYWORDS: Seaweeds, Living Resources, Medicinal Properties

INTRODUCTION

Seaweeds or marine macro algae are non-flowering plants occurring in the sea, estuaries and backwaters and most of them are attached to rocks by holdfast and also grow on other plants as epiphytes. Seaweeds are really not weeds but form one of the important living resources of the ocean, and have both economical and commercial importance Seaweeds have been known to produce compounds with interesting biological and pharmaceutical properties. For centuries, many of the seaweed secondary metabolites (SSM) have been used for traditional medicines due to their therapeutic potentials (Fitton *et al*., 2007). Biological compounds extracted from seaweed families namely Phaeophyceae, Rhodophyceae and Chlorophyceae were proven to have potential medicinal activities such as antioxidant, anti inflammatory, antibacterial, antiviral, anticoagulant and apoptotic activity (Chathurvedi *et al*., 2011)

Lesser exploitation and limited usage are the main reasons why the rich potential of seaweeds in India remains to be an untapped marine resource. Being a plant of unique structure and biochemical composition, seaweed could be exploited for its multi-functional properties in the form of food, energy, medicine and cosmetics.

MEDICINAL USES

An earliest record of seaweed utilization dates to 13,000 years ago at late Pleistocene settlement in Chile. Other archaeological evidences also indicate that seaweeds have been included in folk medicine for thousands of years ago in Japan (13,000-300 BC), China (2700 BC), Egypt (1550 BC) and India (300 BC) (NAAS, 2003; Teas, *et al*., 2005). Seaweeds were the source of about 35% of newly discovered chemicals followed by sponges (27%) and cnidarians (22%) between 1977 and 1987 (Smit, 2004). Of the 7000 marine natural products that have been isolated 25 % of them are from marine macro algae (Kijjoa and Sawangwong, 2004). This data shows the increasing trend of discovery of pharmacologically active compounds from seaweeds.

Seaweeds are considered a source of bioactive compounds as they are able to produce a great variety of secondary metabolites characterized by a broad spectrum of biological activities. Although seaweeds grow in harsh environments, they seldom suffer any serious photodynamic damage during metabolism, which implies some protective compounds and mechanisms in them (Matsukawa *et al.,* 1997). Since seaweeds are a good source of antioxidants, antimicrobial compounds, ω3 fatty acids, and other bioactive compounds, there is an interest to utilize these products as nutraceuticals and in functional foods (Yuan, 2008). Marine algae serve as important resources for bioactive natural products (Iliopoulere *et al.*, 2002 and Metzger, *et al.*, 2002) and Scientists at the National Cancer Institute (NCI) in Bethesda, supports that sea plants contain a remarkable spectrum of components valuable for human health.

Antioxidant Activity

Antioxidant compounds play an important role against various diseases like chronic inflammation, atherosclerosis, cancer, cardiovascular disorders and ageing processes (Kohen and Nyska, 2002), which explains their considerable commercial potential in medicine, food production and the cosmetic industry. Moreover, interest in employing antioxidants from natural sources is considerably enhanced by consumer preference for natural products and concern about the potential toxic effects of synthetic antioxidants (Safer and al-Nughamish, 1999).

Marine algae, like other photosynthesizing plants, are exposed to a combination of light and oxygen that leads to the formation of free radicals and other strong oxidizing agents. However, the absence of oxidative damage in the structural components of macroalgae (i.e., polyunsaturated fatty acids) and their stability to oxidation during storage suggest that their cells have protective antioxidative defense systems (Fujimoto, 1990 and Matsukawa *et al.*, 1997). In fact, algae have protective enzymes (superoxide dismutase, peroxidase, glutathione reductase, catalase) and antioxidative molecules (phlorotannins, ascorbic acid, tocopherols, carotenoids, phospholipids, chlorophyll related compounds, bromophenols, catechins, mycosporine-like amino acids, polysaccharides, etc.) which are similar to those of vascular plants (Fujimoto, 1990; Le Tutour *et al.*, 1998; Rupérez *et al.,* 2002 and Yuan *et al.,* 2005).

Fresh seaweeds are known to contain reactive antioxidant molecules, such as ascorbate and glutathione (GSH), as well as secondary metabolites, including carotenoids (α- and β-carotene, fucoxanthin, astaxanthin), mycosporine like amino acids (mycosporine-glycine) and catechins (e.g., catechin, epigallocatechin), gallate, phlorotannins (e.g., phloroglucinol), eckol and tocopherols (α-, χ-, δ- tocopherols) (Yuan *et al.*, 2005). Terpenoids, polyphenols, phenolic acids, anthocyanins, hydroxycinnamic acid derivatives and flavanoids form other important antioxidant molecules from macroalgae (Bandoniene and Murkovie, 2002).

Many phenolic compounds from seaweeds have demonstrated high antioxidant activity like stypodiol, isoepitaondiaol, taondiol, terpenoids etc. (Nahas *et al*, 2007). Polyphenols constitute important antioxidant molecules of plant origin. Polyphenolics like catechin, epicatechin and gallate showing antioxidant activity has been isolated from Halimeda sp. (Devi *et al.*, 2008). Phlorotannins isolated from *Sargassum pallidum* and *Fucus vesiculosus* have also shown significant antioxidant properties (Ye *et al*. 2008; Díaz-Rubio *et al*, 2011)

Sulfated polysaccharides are another group of compounds isolated from seaweeds having antioxidant properties. Sulfated polysaccharides like Fucoidan, alginic acid and laminaran from *Turbinaria* have demonstrated antioxidant activity (Chattopadhyay *et al*, 2010). Many other sulfated polysaccharides extracted from seaweeds like sulfated galactans, galactans, sulfated glycosaminoglycan, porphyran etc have also shown significant radical scavenging properties

(Rocha de Souza *et al.*, 2007; Josephine *et al*, 2007; Luo *et al*., 2009; Costa *et al.*, 2010; Barahona *et al*, 2011). Souza *et al.*, (2012) isolated sulfated polysaccharides by aqueous extraction from the red seaweed *Gracilaria birdiae* and observed that the slimy substance exhibits moderate antioxidant properties as measured by DPPH free-radical scavenging effect. Galactans, Fucoidan from L. vadosa and the sulfated galactan from *Schizymenia binderi*, exhibited the highest antioxidant capacity by the oxygen radical absorbance capacity (ORAC) method. Barahona *et al.,* (2011). Sulfated polysaccharides having immense antioxidant potential has been isolated from *Corallina sertularioide*, *Dictyota cervicornis*, *Sargassum filipendula* and *Dictyopteris delicatulain* showing reducing power and ferrous ion chelating activities (Costa *et al.*, 2010).

Antibacterial Properties

The production of inhibitory substances by seaweed was noted as early in 1917. Although seaweeds grow in a harsh environment, they seldom suffer any serious photodynamic damage during metabolism. This fact implies that seaweed cells have some protective compounds and mechanisms (Matsukawa *et al.*, 1997). These secondary metabolites impart defense mechanism against herbivores, fouling organisms and pathogens and even chemical defense mechanisms against herbivore; for example, grazer- induced mechanical damage triggers the production of chemicals that acts as feeding deterrents or toxins in seaweeds (Watson and Cruz –Rivera 2003). This can be attributed to be the reason for their bactericidal or anti microbial properties.

A large number of algal extract products have been reported to have antimicrobial activity (Yolanda and Morales, 2004). Many of the structures were identified as fatty acids and hydroxyl unsaturated fatty acids, glycolipids, steroids, phenolics and terpenoids. Lauric acid, palmitic acid, linolenic acid, oleic acid, stearic acids are known to be potential antibiotic or antifungal agents (Unci Ney *et al.*, 2006). Laminarin is one of the major polysaccharides found in brown algae is a dietary fiber which can act as a prebiotic and also having antiviral and antibacterial properties [O'Doherty, *et al*. 2010]. Sulfated polysaccharides inhibit activity of many bacterial species as well as viruses (Leonard, *et al*., 2010). Polysaccharides can act as prebiotics (substances that stimulate the growth of beneficial bacteria in the digestive track) and exert growth-promoting and health-improving effects.

Compounds, such as polyphenols, flavonoids and polysaccharides, having antioxidant and antimicrobial activities have been detected in brown, red and green algae (Cox *et al.*, 2009; Zaragoza *et al.*, 2008). Acrylic acid is the common antibacterial component that occurs in many red, brown and green algae (Challenger *et al*., 1957; Katayama, 1962; Sieburth, 1969,). Some authors have reported antibacterial activity of brominated phenols, polyphenols, tannins and tannic acid (Ogino and taki, 1957; Peguy, 1964; Sieburth and Conover, 1965; Craigie and Gruenig, 1967). Volatile organic acid called Sarganin complex isolated from *Cympolin birbata* and *Sargassum natans* showed broad spectrum antibacterial activity (Martinez *et al*, 1963, 1964). Nagayama *et al.*, (2002) reported strong bactericidal activity of brown-algal phenolic compounds (phlorotannins), such as eckol and eckol related compounds, from *Ecklonia kurome*.

A series of polyphenolic compounds such as catechins, flavonols and flavonol glycosides identified from methanol extracts of red and brown algae are found to have antioxidant and antimicrobial activities (Hosokawa *et al.*, 2006). Horie *et al.* (2008) isolated sargaquinoic acid derivatives from the brown alga *Sargassum sagamianum* having antibacterial properties. Organic acids and phenolic compounds, especially polyphenols and tannins have also been shown to have anti microbial activities (Glombitza, 1979; Chuyen *et al.*, 1982).

Katayamma (1962) observed that terpenes isolated from seaweeds inhibit growth of *Staphylococcus aureus* and *Eschericia coli*. Caulrpenyne, a sesquiterpene active against gram positive bacteria was isolated from green alga, Caulerpa prolifera (Amico *et al.,* 1978). A diterpenoid showing antimicrobial activity was isolated from the brown seaweed *Dictyota baratayresii* (Norris and Fenical, 1982).

Anticancer Properties

Marine macroalgae are the most interesting algae group because of their broad spectrum of biological activities such as anticancer activities (Kim *et al.,* 2011), The lower incidence of breast cancer in the Japanese and Korean Populations (Teas, 1983; Adami *et al.,* 1998: Lawson *et al*., 2001) has intrigued researchers. Researchers have found that dietary brown algae and their extracts inhibit carcinogen-induced breast cancers, lung metastases, and leukemia in animal models. (Ohigashi *et al*., 1992; Itoh, *et al*., 1995; Riou, *et al.,* 1996; Funahashi *et al.,* 1999; Funahashi *et al*., 2001). Similarly, tests on the seaweed extracts in bacterial systems revealed that the extracts had a profound antimutagenic quality (Reddy *et al.,* 1984; Okai, *et al.,* 1993).

Japanese women typically suffer from very low levels of estrogen related cancers (breast and cervical) and it is thought that this is due, in part, to the high levels of brown seaweed that they ingest. Incorporating the brown seaweeds *Laminaria* and *Fucus vesiculosus* into the diet has been shown to prolong the length of the menstrual cycle in women and to exert anti-estrogenic effects that may be responsible for the reduced risk of estrogen related cancers (Teas, 1996; Skibola, 2004). Seaweeds are also a good source of the trace element selenium which is currently attracting a lot of attention regarding its potential anticancer properties (Black, 2006).

The anti-cancer properties of extracts and bioactive components of marine algae are discussed here.

Aqueous extracts of *Gracilaria corticata* (Zandi *et a*l., 2010) and *Sargassum oligocystum* (Zandi *et al*., 2010) inhibited the proliferation of human leukemic cell lines. Both ethanol (Farooqi *et al.,* 2011) and methanol (Yeh *et al*., 2012) extracts of *Gracilaria tenuistipitata* reportedly had anti-proliferative effects on Ca9-22 oral cancer cells and were involved in cellular apoptosis, DNA damage, and oxidative stress. Similarly, caspase-dependent apoptosis induced by a methanol extract of *Plocamium telfairiae* has been demonstrated using HT-29 colon cancer cells.(Kim *et al.,* 2007).

The compound Condriamide-A from *Chondria* sp. exhibits cytotoxicity towards human nasopharyngeal and colorectal cancer cells (Palermo, *et al*., 1992). Caulerpenyne from *Caulerpa* sp. shows its bioactivity against human cell lines and to have anticancer and antiproliferating properties.

Among green algae, a hot water extract of *Capsosiphon fulvescens* that contained polysaccharides induced the apoptosis of gastric cancer cells (Park *et al.,* 2006; Kwon and Nam 2007; Kim *et al.*, 2012). Dimethylsulfonio propionate, a tertiary sulfonium metabolite found in green algae and other algae species, exhibited anti-cancer effects in mice with Ehrlich ascites carcinoma (Nakajima *et al*., 2009).

Studies of brown algae have shown that glycoproteins from *Laminaria japonica* (Go *et al.,* 2010). and fucoidans from *Sargassum hornery, Eclonia cava*, and *Costaria costata*. (Ermakova *et al.,* 2011) had anti-cancer effects on human colon cancer cells. Heterofucans from *Sargassum filipendula* exhibited anti-proliferative effects on cervical, prostate, and liver cancer cells (Costa *et al.,* 2011). Chemoprevention is one of the most important strategies in the control of cancer development, molecular mechanism-based cancer chemoprevention using carotenoids seems to be an attractive approach (Tanaka *et al.,* 2012). A carotenoid fucoxanthin inhibit the growth of LNCap prostate cancer cells by arresting these cells in

the G1 phase (Satomi, 2012). Studies have shown that a sulfated polysaccharide purified from the brown alga *Eclonia cava* species selectively and dose-dependently suppresses the proliferation of the cancer cell lines *in vitro* (Athukorala *et al*., 2006).

Finally, it may be added here that, owing to a diverse chemical ecology, seaweeds have a great promise for providing potent anticancer agents.

CONCLUSIONS

Seaweeds are consumed extensively by Indonesians, Japanese and Koreans who have understood the nutritional properties. Eventhough there are reports of seaweeds used as food in many asian countries years back, valuable health benefits of these seaweeds are yet to be exploited by Indians. It is reported that seaweeds like *Ulva lactuca*, *Ulva reticulata*, *Enteromorpha intestinalis, Acanthophora spicefera*, *Gracilaria edulis*, *Padina tetrastomatica* and *Sargassum wightii* are highly concentrated in the coastal belt of Gulf of Mannar, Rameswaram to Kanniyakumari in Tamil Nadu. They are also available throughout the year and can be stored for long periods in dry form. But still there are discrepancies in the effective utilization of these resources as a food item.

Being a plant of unique structure and biochemical composition, seaweed could be exploited for its multi-functional properties in the form of food, energy, medicine and cosmetics. Seaweeds do not absorb toxic amounts of any element and provides hundreds of organic compounds. In this context, we can think about utilizing seaweeds as a cheap source of dietray protein and fibre. The benefit of including seaweeds in our daily diet increases longevity, enhances immune functioning, revitalize the cardiac system, endocrine, digestive and nervous systems. Seaweed has also been found traditionally useful to cure a variety of maladies. Seaweeds can also offer to be a wonderful candidate for utilizing the apparently untapped resource taking in to account of its high nutritive and therapuetic potential.

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